

XMUT310 Mock Exam 2025 T2

Question 1: Digital Baseband and BER [20 marks]

a) A binary communication system uses Polar NRZ signaling with rectangular pulses. The system operates at a Bit Error Rate (BER) of 10^{-6} . If the transmitted signal power is doubled, determine the new BER. Use the table of $Q(x)$ values provided in the table.

Hint: Begin by identifying the correct P_e formula for Polar NRZ. Relate the signal power to the energy per bit, E_b . Then, find the argument of the Q -function for the original BER. Finally, calculate the new argument and the corresponding BER.

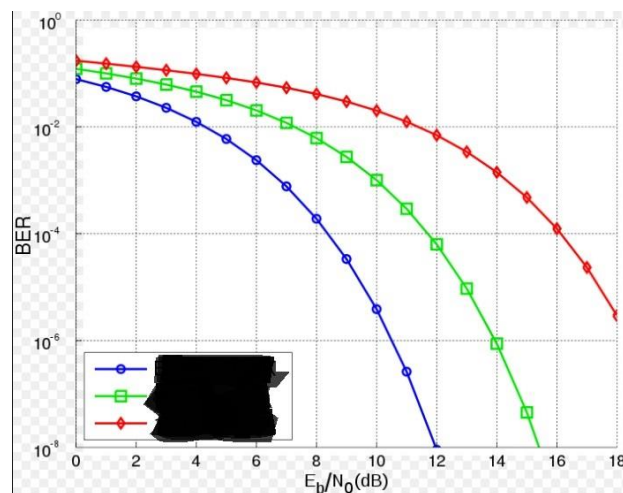
[15 marks]

b) What does the result from part (a) tell you about the relationship between transmitted power and error performance in a digital communication system?

[5 marks]

Question 2: BER Performance of Digital Modulations [30 marks]

Figure 1 below shows the Bit Error Rate (BER) versus E_b/N_0 (in dB) for different digital modulation schemes: Binary PSK (BPSK), QPSK, 8-PSK and 16-PSK.



a) Explain the information this BER plot provides. Compare the schemes from two perspectives:

i) For a fixed target BER of 10^{-5} .

ii) For a fixed E_b/N_0 of 10 dB.

[8 marks]

b) On your answer script, label which curve in Figure 1 corresponds to BPSK, QPSK, 8-PSK and 16-PSK. Justify your reasoning.

[8 marks]

c) In this plot, BPSK and QPSK have identical BER performance. Explain why this is the case.

[6 marks]

d) Compare 16-PSK and BPSK in terms of their **bandwidth efficiency** and **error performance**. Quantify your answer using the plot (e.g., "at a BER of 10^{-4} , 16-PSK requires approximately X dB more E_b/N_0 than BPSK").

[8 marks]

Question 3: Pulse Code Modulation and Line Coding [20 marks]

a) A PCM system is designed to quantize an analog signal that has a peak-to-peak voltage of 2 V. The required Signal-to-Quantization-Noise Ratio (SQNR) at the output must be at least 40 dB.

- i) Determine the minimum number of bits per sample required.
- ii) Calculate the exact SQNR (in dB) achieved using this number of bits.

[11 marks]

b) For the following binary data sequence 1 0 1 1 0 0 1 0, draw the baseband line code waveforms for:

- i) Unipolar Return-to-Zero (RZ) with a 50% duty cycle.
- ii) Manchester code.
- iii) Polar Non-Return-to-Zero (NRZ).

[9 marks]

Question 4: Maximum Bit Rate Calculation [10 marks]

A binary system uses unipolar NRZ signaling, where a binary '1' is represented by a +2 V pulse and a binary '0' is represented by 0 V over the interval $(0, T)$. The channel introduces Additive White Gaussian Noise (AWGN) with a power spectral density of $N_0/2 = 5 \times 10^{-6}$ W/Hz. If the average probability of error must not exceed 10^{-5} , what is the maximum bit rate that can be achieved? Assume the bits are equally likely.

[10 marks]